A SCIENTIFIC STUDY

Comparative Analysis of Energy Consumption and CO_2 Emissions of Road Transport and Combined Transport Road/Rail

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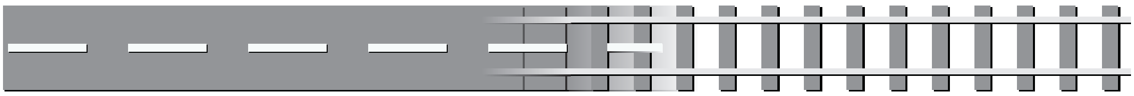


Executive Summary and Conclusions by:

IRU International Road Transport Union

BGL Unterwegs nach morgen

INTRODUCTION

"Freight belongs on the rails!" This slogan is based on the assumption that rail-freight transport consumes less primary energy and produces less CO_2 than road transport. For bulk freight transport over long distances by direct rail link, this might be true. When it comes to smaller shipments and destinations which lack their own rail sidings, however, the situation is quite different.

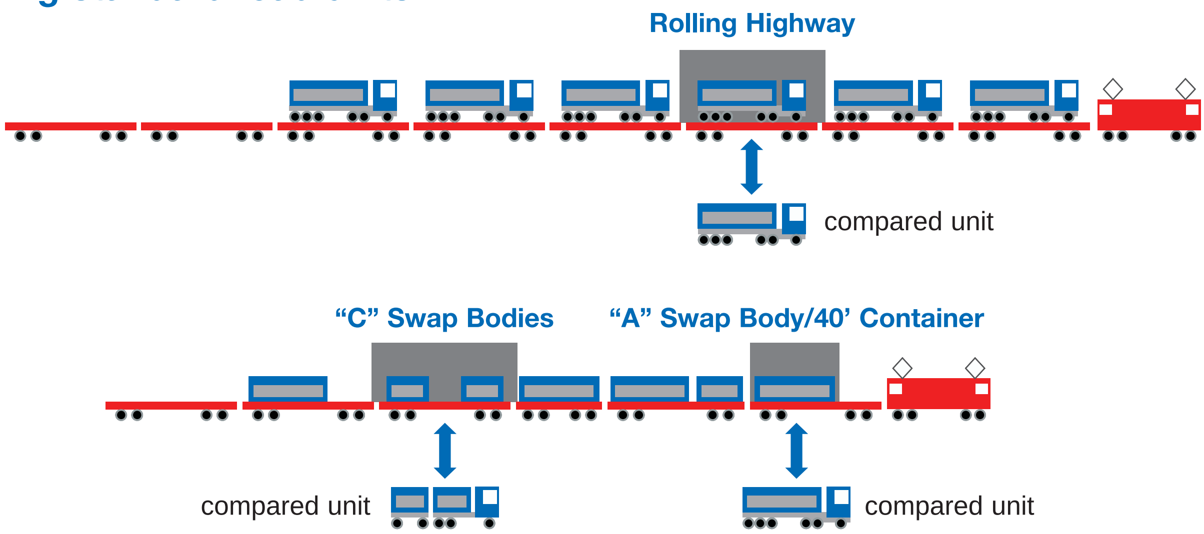
Claims that the environmental advantages offered by all-train transport justify transferring freight from the road to the rail should be regarded with some scepticism. Firstly, with very few exceptions, freight cannot be transported door-to-door by train – lorries have to fill the gap. Secondly, much freight involves no more than a single lorry-load carried from point A to point B. If transported by rail, the load would be part of a train grouping together various individual wagon-loads, most of which would have to be transported further than if they went directly by road. Finally, each load would have to be transhipped twice along the way, once from the lorry that delivered it to the rail depot and once back onto a lorry for final delivery.

The complexity of this subject prompted the Bundesverband Güterkraftverkehr Logistik und Entsorgung (BGL) e.V. and the International Road Transport Union (IRU) to commission a joint study by the Institut für Energie- und Umweltforschung (IFEU) in Heidelberg and the Studiengesellschaft für den Kombinierten Verkehr (SGKV) in Frankfurt a.M. The research consisted of a comparison between primary energy consumption and CO_2 emissions of pure road transport on the one hand and combined road/rail transport on the other.

The objective of the study was to compare key environmental impacts of transporting, over a given European route, one load unit by road only and the same load unit by combined transport road/rail. In contrast to previous studies, energy consumption and CO_2 emissions were taken into account for both the initial and final legs carried out by road and for handling operations. Typical load factors were also taken into consideration.

Road haulage in 40-tonne lorries was compared with various combined road/rail transport techniques: container, swap body, semi-trailer and rolling highway – the latter being where the tractor, semi-trailer and driver are transported together by train.

Figure 1: Types of combined transport compared with road transport, using standard load units



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The study compared the primary energy required for road haulage (diesel fuel production and consumption) with that for combined transport (diesel for lorries and trains plus electricity for trains, generated from fossil fuels, nuclear power stations, plus hydro-electric stations and other renewable sources). Electricity calculations were based on actual national figures.

The rail routes selected for the study are "best case" links, where combined transport uses efficient direct "block" trains with high load factors. In the case of road transport, variations in the rate of fuel consumption on motorways, rural roads and urban streets were taken into account. For all types of transport, the effect of gradients along the various routes on energy consumption was included. Total energy consumption and CO_2 emissions for combined transport were broken down between the separate component operations: road feeding, road distribution, main line rail and shunting.

Fuel consumption for a 40-tonne lorry with an average loaded weight was calculated at 34 litres per 100 km. By comparison, a fully loaded 40-tonne lorry consumes on average 39.2 litres per 100 km and an empty one 29.3 litres per 100 km.

A comparison is drawn between the transport by road of a fully loaded lorry unit (i.e. with fuel consumption of 39.2 litres per 100 km) and the same unit in combined transport. The load factors of combined transport trains reflect actual figures for the routes considered.

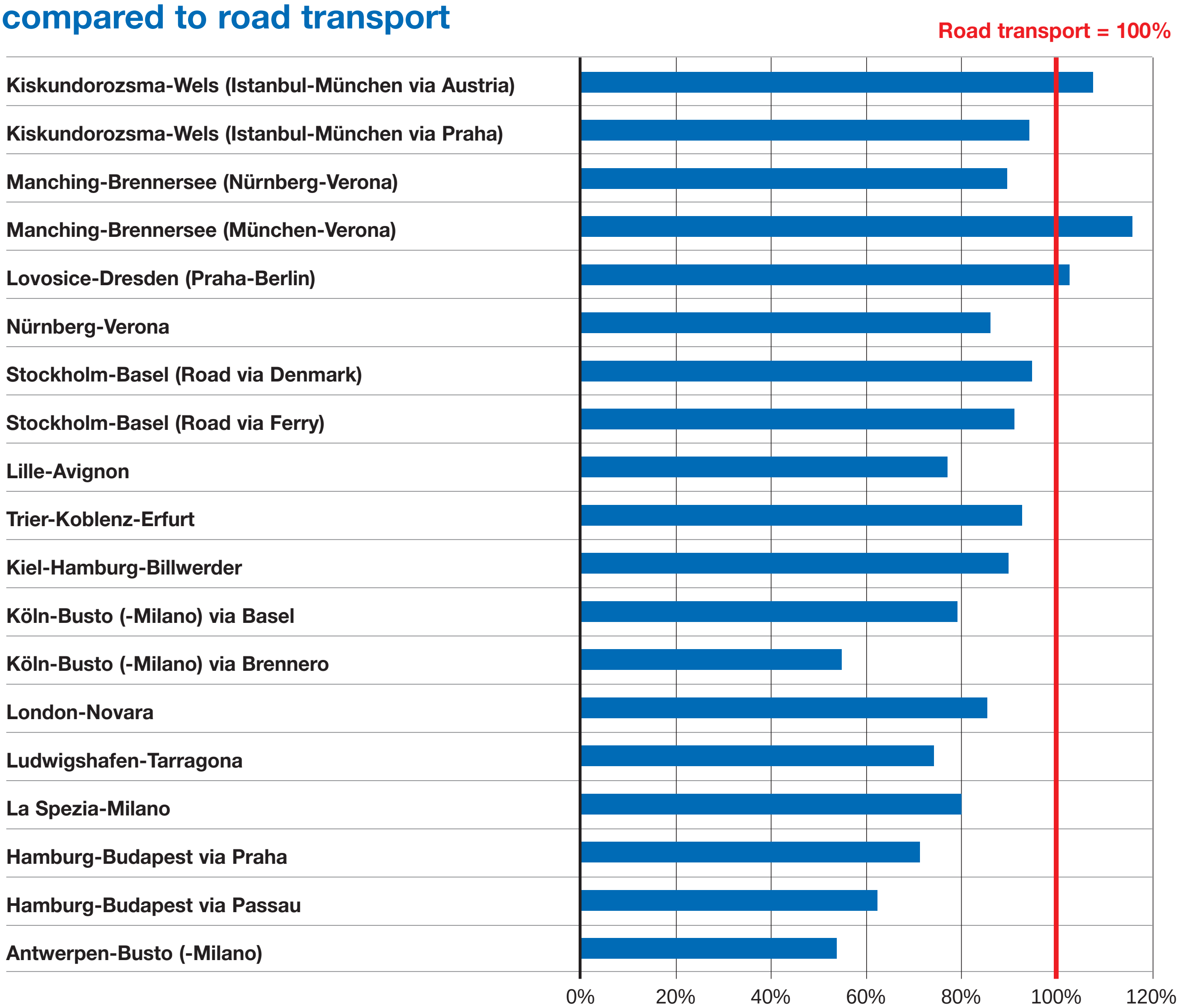
Energy consumption

For the 19 routes studied, the primary energy consumption of combined transport was:

- **in three cases up to 15% higher;**
- **in eight cases up to 20% lower;**
- **in six cases 20-40% lower;**
- **in two cases more than 40% lower;**

than that of pure road transport.

Figure 2: Primary energy consumption: Combined transport road/rail compared to road transport



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Combined transport using the rolling road showed no significant advantages over alternative all-road transport, and in some cases required even higher primary energy consumption.

Unaccompanied transports had better results. The best results were achieved by swap bodies and containers.

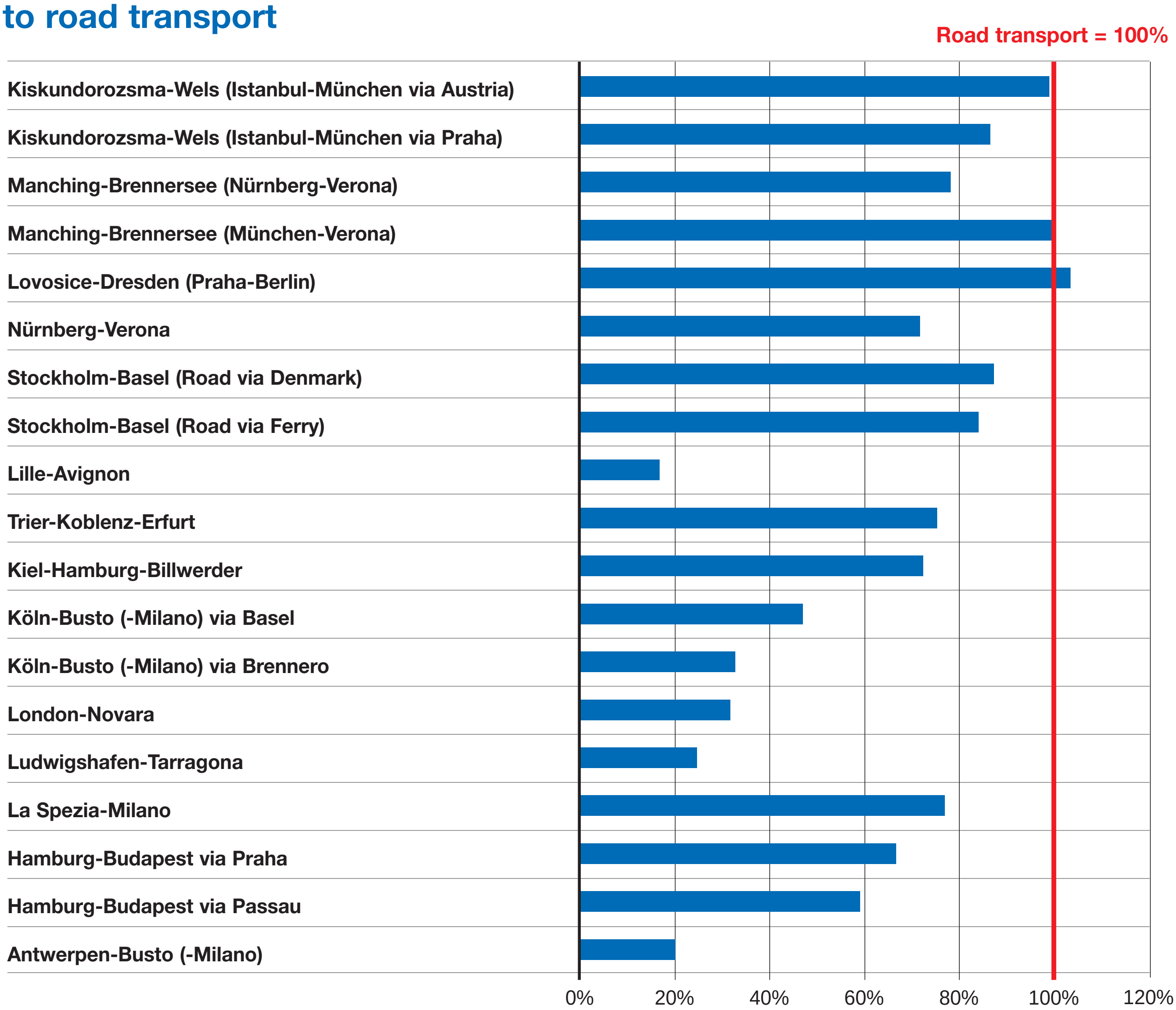
CO_2 emissions

CO_2 emissions from combined transport were:

- **in two cases up to 3% higher;**
- **in four cases up to 20% lower;**
- **in seven cases 20-50% lower;**
- **in six cases more than 50% lower;**

than those generated by pure road transport.

Figure 3: CO_2 emissions: Combined transport road/rail compared to road transport



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The higher the nuclear component in the electricity-generation mix used to power trains, the lower the overall CO_2 emissions generated by combined transport. Thus, a unit of electricity for Czech railways (largely from fossil fuel power stations) results in CO_2 emissions more than 12 times higher than for the same unit for French railways (more than 80% of France's electricity comes from nuclear power plants).

Train load factors:

The environmental friendliness of combined transport stands or falls according to the load factor and length of the trains involved. For extraneous reasons (maximum train weight) it is often impossible to fully exploit the loading capacity of combined-transport trains. The shorter the train and the lower its load factor, the worse its environmental efficiency.

Table 1: Minimal load factors for combined transport to be better than road transport in primary energy consumption and CO_2 emissions (total relation with all other parameters fixed)

Route	Average CT load factor	Primary energy	CO_2 emissions
Kiskundorozsma-Wels (Istanbul-München via Praha)	65%	>50%	>35%
Kiskundorozsma-Wels (Istanbul-München via Austria)	65%	>85%	>55%
Manching-Brennersee (München-Verona)	90%	>100%	>90%
Manching-Brennersee (Nürnberg-Verona)	90%	>64%	>43%
Lovosice-Dresden (Praha-Berlin)	80%	>85%	>95%
Hamburg-Budapest via Passau	90%	>44%	>41%
Hamburg-Budapest via Praha	90%	>53%	49%
Stockholm-Basel (Road via Denmark)	85%	66%	50%
Stockholm-Basel (Road via Ferry)	85%	59%	44%
Köln-Busto (-Milano) via Brennero	90%	38%	19%
Köln-Busto (-Milano) via Basel	90%	62%	30%
Nürnberg-Verona	80%	61%	46%
Antwerpen-Busto (-Milano)	80%	29%	6%
London-Novara	90%	69%	15%
Ludwigshafen-Tarragona	90%	55%	12%
La Spezia-Milano	90%	60%	56%
Lille-Avignon	90%	57%	5%
Trier-Koblenz-Erfurt	75%	65%	46%
Kiel-Hamburg-Billwerder	70%	59%	44%

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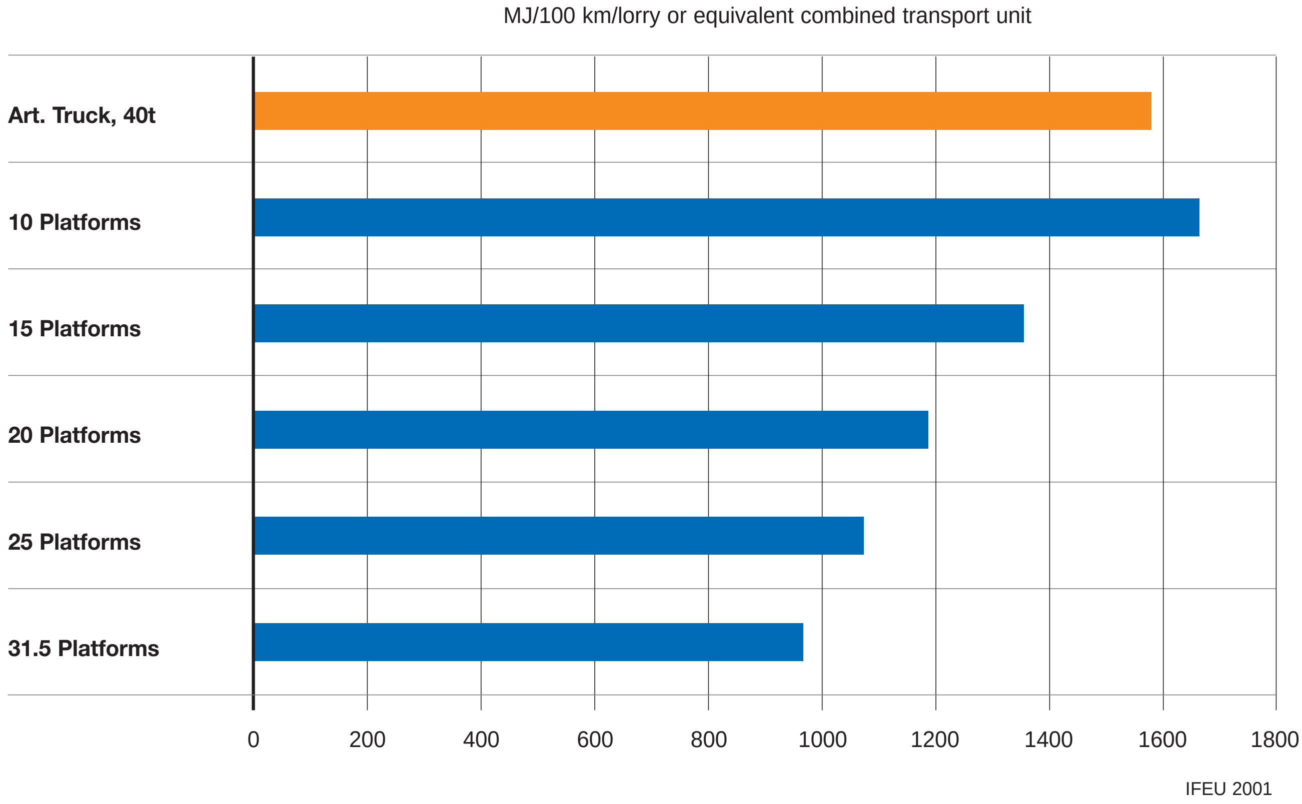
Figure 4: Specific primary energy consumption – articulated 40t lorry and combined transport trains of various lengths (Train C6 Hamburg-Budapest)



Example

Swap-body combined transport trains between Cologne and Milan via Basel achieve an average load factor equal to 90% of full capacity. When this combined transport train's load factor drops below 62%, its energy consumption exceeds that required to transport the swap bodies entirely by road. When the load factor drops below 30%, the CO_2 emissions from combined transport also exceed those of pure lorry transport.

Primary energy consumption for the transport of a container from Hamburg to Budapest is higher using a lorry for the whole distance than for combined transport provided that the train in question carries 15 or more containers. When that figure drops to 10, all-road transport is more efficient.

Position of the point of origin and the destination

■ Unless the road route from the point of origin to the departure rail terminal goes in more or less the same direction as the rail route from the departure terminal to the arrival terminal, the total distance travelled for combined transport will be longer than for all-road transport. In such cases combined transport presents considerable environmental inefficiencies. The shorter the distance to the nearest rail terminal both from the departure point and from the final destination, the greater the environmental efficiency of combined transport.

Figure 5: Simulation of "break-even distances" for feeding and delivery

Combined transport road/rail and road transport scenarios offering equal energy consumption

Direction of feeding and delivery aligned with main rail route

Direction of feeding and delivery in opposite direction to the main rail route

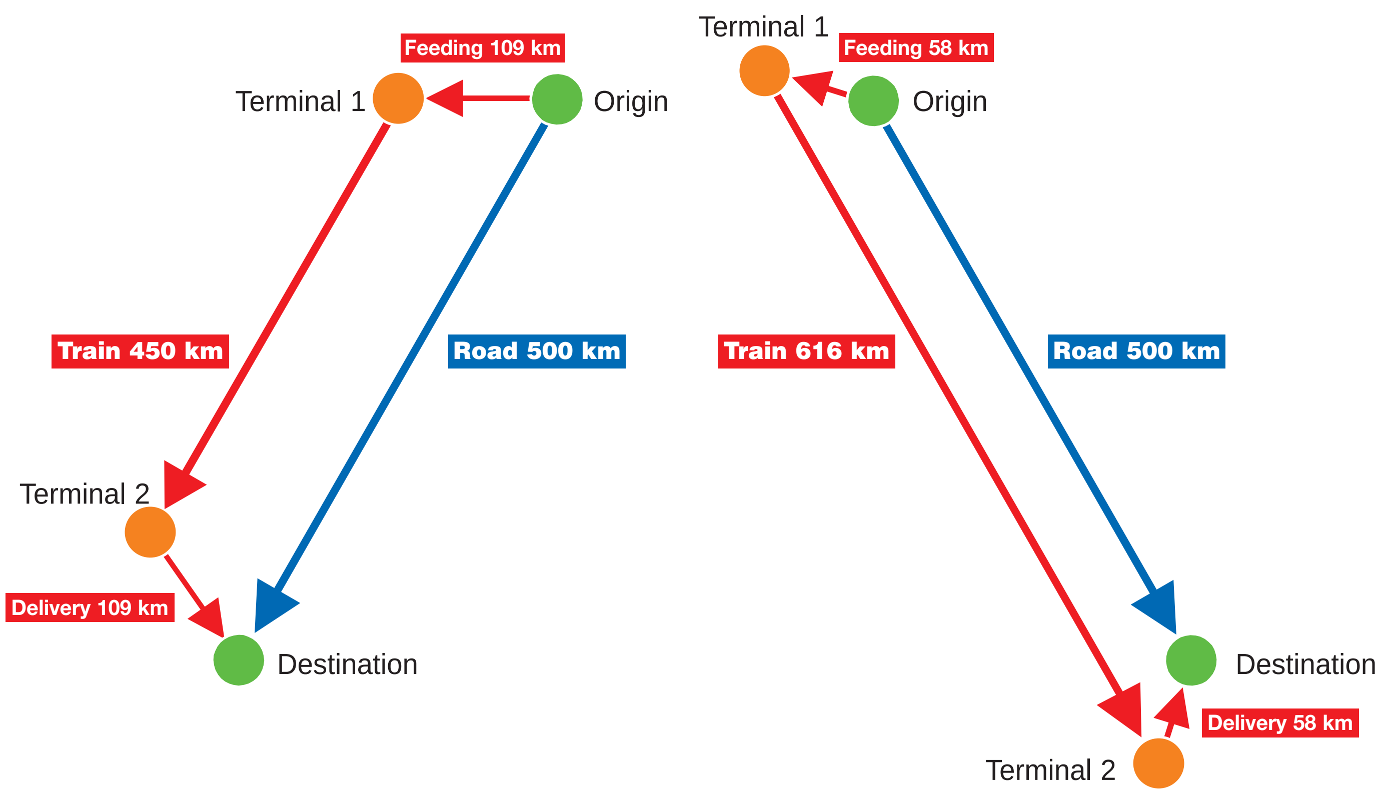


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Table 2: Loading units, load factors and distances for the European relations

Route	Load Unit	Load Factor Train	Distance (km) Combined Road/Rail Feed.	Del.	Train	Total	Road Total
Kiskundorozsma-Wels (Istanbul-München via Praha)	40t lorry	65%	1222	249	648	2119	2352
Kiskundorozsma-Wels (Istanbul-München via Austria)	40t lorry	65%	1222	249	648	2119	2066
Manching-Brennersee (München-Verona)	40t lorry	90%	74	237	306	617	437
Manching-Brennersee (Nürnberg-Verona)	40t lorry	90%	92	237	306	635	605
Lovosice-Dresden (Praha-Berlin)	40t lorry	80%	63	194	117	374	342
Hamburg-Budapest via Passau	40' Cont.	90%	-	20	1243	1263	1365
Hamburg-Budapest via Praha	40' Cont.	90%	-	20	1243	1263	1225
Stockholm-Basel (Road via Denmark)	Semi-Trailer	85%	650 Road 200 Ferry	30	914	1794	1937
Stockholm-Basel (Road via Ferry)	Semi-Trailer	85%	650 Road 200 Ferry	30	914	1794	650 Road S 200 Ferry 884 Road D
Köln-Busto (-Milano) via Brennero	2 x "C" Swap-Bodies	90%	10	36	852	898	1204
Köln-Busto (-Milano) via Basel	2 x "C" Swap-Bodies	90%	10	36	852	898	830
Nürnberg-Verona	Semi-Trailer	80%	30	30	642	702	606
Antwerpen-Busto (-Milano)	40' Cont.	80%	30	36	963	1029	1302
London-Novara	"A" Swap-Body	90%	50	30	1343	1423	1271 Road 40 Eurotunnel
Ludwigshafen-Tarragona	40' Cont.	90%	4	20	1318	1342	1385
La Spezia-Milano	2 x 20' Cont.	90%	-	25	230	255	222
Lille-Avignon	Semi-Trailer	90%	30	30	815	875	915
Trier-Koblenz-Erfurt	Semi-Trailer	75%	20	20	500	540	430
Kiel-Hamburg	2 x 20' Cont.	70%	-	-	110	110	114

Source: SGKV, IFEU 2001

Example 1

The road distance from Munich to Verona is 437 km. If the shipment is made using the rolling highway (i.e. Manching - Brennersee), the distance is increased to 617. In this case, combined transport not only requires greater primary energy consumption than all-road transport but causes more CO_2 emissions as well.

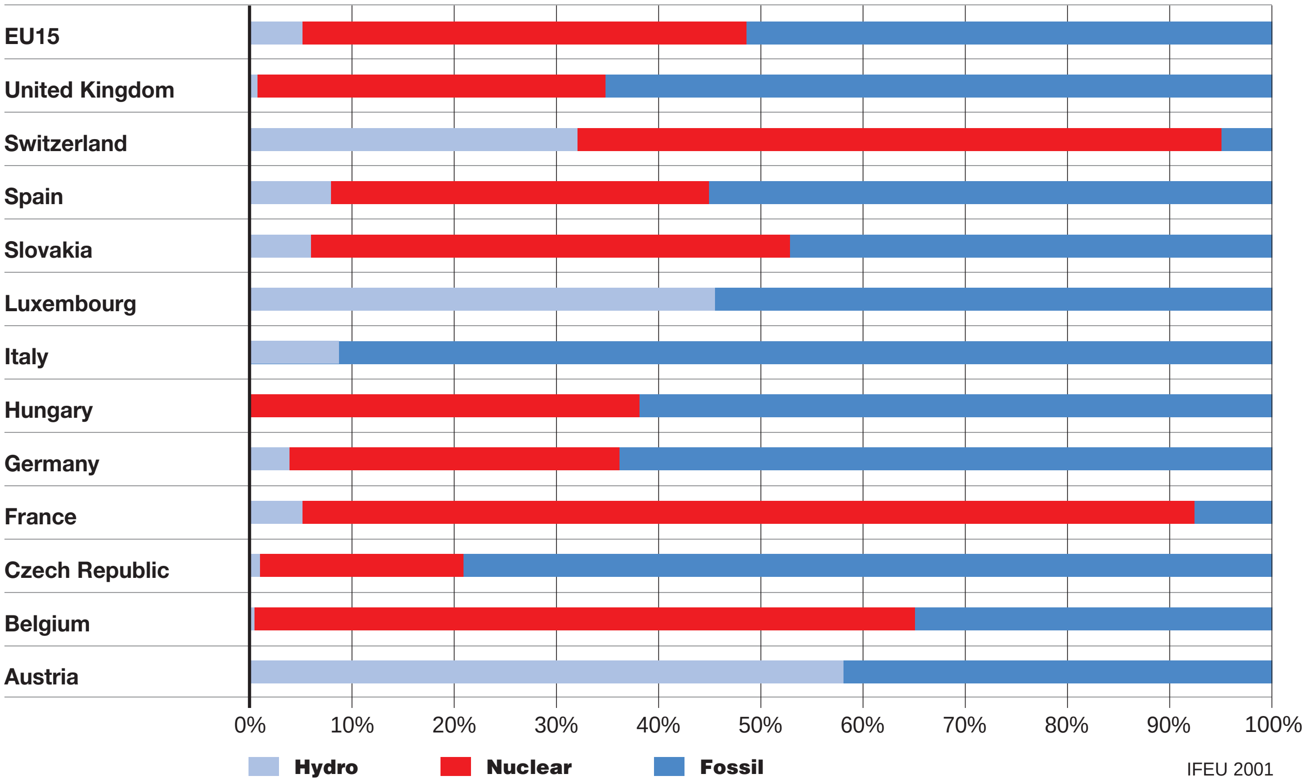
Example 2

When a combined transport shipment is made from Cologne to Busto, the initial road feeding in Cologne is over a distance of only 10 km and the final road delivery in Italy takes the shipment onwards in the same overall direction. For a shipment from Koblenz to Varese, however, the initial feeding is longer and both feeding and delivery are in the opposite direction to the overall journey. In this case, the environmental efficiency of combined transport is clearly reduced.

Energy mix

The environmental friendliness of combined transport also depends on the way in which the electricity used by the train is generated. For example, the greater the nuclear component in the mix, the less the volume of CO_2 released into the atmosphere as a result of the rail component. Paradoxically, combined transport therefore appears particularly “environment-friendly” in those countries whose electricity production is most dependent on nuclear power. Because of the risks associated with nuclear power and the absence of a reliable long-term solution for radioactive waste, its overalll costs and environmental impact are impossible to calculate.

Figure 6: Energy sources for electricity production in different European countries



Example

Almost 90% of the electricity generated in France comes from nuclear power, whereas in the Czech Republic, nearly 80% is produced using fossil fuels. The result is that a given unit of electricity consumed by rail transport in the Czech Republic generates more than 12 times the amount of CO_2 emissions than the same unit of electricity in France. When the Lovosice-Dresden rolling highway is used on the Prague-Berlin route, the resulting CO_2 emissions are higher than they would be if the same load were carried entirely by road.

Type of load unit

■ The degree of environmental-friendliness in combined transport increases or decreases depending on the load unit used. The most efficient combined transport solutions are containers and swap bodies since they have the lowest empty weight. Combined transport becomes less efficient with semi-trailers as the chassis makes for a higher empty weight. The least efficient is the rolling highway since the entire lorry is loaded on special low-floor wagons, which results in a very high empty weight.

Table 6: Parameters of typical combined trains

Train No.	Route	Typical loading unit	Empty weight wagons (t)	No. of platforms	Average wagon weight/platform (t)
RR1	Kiskundorozsma-Wels	40t lorry	390	18	21.7
RR2	Manching-Brennersee	40t lorry	373	18	20.7
RR3	Lovosice-Dresden	40t lorry	473	25	18.9
ST1	Nürnberg-Verona	Semi-Trailer	405	24	17.2
ST2	Lübeck-Basel	Semi-Trailer	567	28	20.2
ST3	Lille-Avignon	Semi-Trailer	553	30	18.4
ST4	Trier-Koblenz-Erfurt	Semi-Trailer	496	32	15.5
C1	Kiel-Hamburg-Billwerder	2 x 20’ Containers	263	18	14.6
C2	Köln-Busto	2 x “C” Swap Bodies	482	25	19.4
C3	London-Novara	“A” Swap Body	476	26	18.3
C4	Ludwigshafen-Tarragona	30’ Container	270	23	12.0
C5	La Spezia-Milano	2 x 20’ Containers	500	30	16.7
C6	Hamburg-Budapest	40’ Container	470	32	14.9
C7	Antwerpen-Busto	40’ Container	424	36	11.8

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CONCLUSIONS

There is no such thing as a truly environment friendly means of transport. Combined transport is not inherently superior to pure road transport in terms of environmental impact, as measured by energy consumption and CO_2 emissions.

The impending introduction of Euro 4 and 5 motors for commercial vehicles will bring a further reduction in EU limits on emission levels of specific harmful substances, to the point where environmental efficiency of transport will be measured mainly in terms of primary energy consumption and CO_2 emissions.

In this respect, the conclusions of the study are clear: shifting freight from lorries onto trains does not automatically cut primary energy consumption or CO_2 emissions. Even if the most optimistic projections for switching freight traffic from trucks onto trains could be realised, virtually no significant energy savings would be achieved.

While it is true that unaccompanied combined transport generally consumes less primary energy than all-road transport, combined transport using rolling highway is rarely more environmentally efficient than all-road transport. The advantages offered by combined transport in terms of CO_2 emissions are markedly less than commonly assumed in political circles. The lower CO_2 emissions provided by combined transport are achieved only because of the high proportion of nuclear power used in the generation of electricity for railways.

It should be borne in mind that the researchers drew their comparisons using routes where combined transport performs best, i.e. they only considered the most environmentally efficient road/rail transport operations.

The message to politicians is clear: The sweeping slogan “Freight belongs on the rails!” is incorrect even from a purely environmental point of view. Combined transport is more environmentally friendly only when external factors permit optimal exploitation of advantages specific to rail transport, i.e. when:

- feeding and delivery go in the same direction as the overall route;
- trains have a high load factor and;
- trains are not shorter than a certain length.

Attempting to serve several destinations within a given area more directly by dividing a few long trains into a greater number of shorter trains is therefore likely to be disadvantageous from an environmental standpoint.

Simply put: In most cases it makes more sense from an environmental viewpoint to send a shipment by road rather than send it on a half-full combined transport train.

Present political restrictions on lorry traffic are causing a growing number of detours which are artificially increasing the distances covered by road transport. If there were fewer political restrictions on lorry traffic, if efforts were made to achieve optimal exploitation of the existing road infrastructure, and if more environment-friendly innovations were encouraged in road transport, the study results would have been even better for all-road transport.

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